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Constraint Ranking Scheme and Learnability

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Abstract

In Optimality Theory terms, language learnability means learning the constraint ranking scheme. During the learning process different grammars are constructed by learners in an attempt to bring their final grammar, i.e. constraint ranking, in agreement with that of an adult native speaker. Differences among such grammars are due to domination relations holding among the interacting constraints. These relations can be changed by learners by means of two reranking strategies, namely: Constraint Demotion and the Gradual Learning Algorithm. Using the first strategy, learners are able to demote, that is move, violated constraints reflecting their wrong (produced) forms downward the constraint hierarchy. On the other hand, the second strategy allows learners to demote violated constraints downward the constraint hierarchy and promote less violated ones upward the hierarchy at the same time. The main difference between these two strategies is that for Constraint Demotion the constraint hierarchy is linear and ordinal whereas for the Gradual Learning Algorithm it is continuous. These two learning reranking strategies can be used by Iraqi learners of English at the university level in their attempt to bring forms they produce in agreement with the ones they correctly comprehend.

جدولة الإشتراطات و التعلم

الخلاصة:

بحسب نظرية التفاضل اللغوية فأن عملية تعلم لغة ما تعني تعلم جدولة الإشتراطات اللغوية الكونية. فخلال عملية التعلم عدة نماذج من القوانين اللغوية تكوّن بغية الوصول إلى الأنموذج الصحيح. إن سبب إختلاف هذه النماذج فيما بينها يرجع إلى علاقات السيطرة و التحكم فيما بينها. و بمقدور المتعلم أن يغير من تسلسل هذه العلاقات بالإستعانة بإستراتيجيتين تعليميتين تتيح الأولى للمتعلم فقط نقل قانون من موقع أعلى ضمن السلسلة القانونية للغة إلى موقع أدنى فيما تمكنه الإستراتيجية الثانية من نقل القوانين من موقع أعلى إلى أدنى أو بالعكس.

1. Introduction:

Optimality Theory (henceforth OT) has been the focus of many linguistic studies since the early nineties of the twentieth century. McCarthy and Prince (1994: 335) state the basic principles of OT as follows:

a. **Universality**. Universal Grammar provides a set Con of constraints that are universal and universally present in all grammars.

b. **Violability**. Constraints are violable; but violation is minimal.

c. **Ranking**. The constraints of Con are ranked on a language particular basis; the notion of minimal violation is defined in terms of this ranking. A grammar is a ranking of the constraint set.

d. **Inclusiveness**. The constraint hierarchy evaluates a set of candidate analyses that are admitted by very general considerations of structural well-formedness.

e. **Parallelism**. Best satisfactions of the constraint hierarchy is computed over the whole hierarchy and the whole candidate set. There is no serial derivation.

Constraints are basically of two types: markedness constraints and faithfulness constraints. Prince and Smolensky (1997: 1605) explain these types of constraints as follows "one class of universal constraints in Optimality Theory formalizes the notion of structural complexity, or markedness. Grossly speaking, an element of linguistic structure is said to be marked if it is more complex than an alternative along some dimensions…(such as) comprehension, production, me-mory, or related physical and cognitive functions." As for the second type of universal constraints, i.e. faithfulness constraints, they (ibid: 1606) mention that:

> an optimal (grammatical) representation is one
> that optimally satisfies the constraints ranking
> among those representations containing a given
> input… the faithfulness constraints tie the success
> of an output candidate to the shape of the cor-
> respondent input; each faithfulness constraint
> asserts that an input and its output should be
> identical in a certain respect.

It is well known in the field of child language that comprehension greatly exceeds production. This means that markedness constraints

outrank faithfulness constraints in children's constraint hierarchy. Smolensky (1996: 17) stipulates that "Learnability … requires the child's initial hierarchy to rank faithfulness below structural constraints." However, this situation gradually changes as children's production becomes identical to adults' production. In other words, in adult grammars faithfulness constraints interleave among markedness constraints. In OT, language learnability means learning the constraint ranking. But, how does the learning task takes place? This is the focus of the following section.

2. Learnability of Grammars:

A grammar of a language is, in OT terms, a hierarchy of constraints. It is the task of the language learner to infer the way a set of constraints is organized by means of interaction reflecting the existence of a certain output form in the language. In order to explain the learning procedure followed by learners, certain algorithms have been suggested. An algorithm is a model of the language learner. In (1993), Tesar and Smolensky developed an algorithm which "demonstrates that it is possible to deduce rankings of constraints on the basis of output forms plus a set of universal constraints …. The key idea is that constraints which are violated in the optimal output must be dominated by one other constraint'," (Kager, 1999:298). According to this algorithm a learner starts with all constraints unranked; then after some learning takes place and knowledge accumulates those constraints stratify and start the ranking process. Upon detecting an error in output forms, the learner demotes certain constraints below others, thus changing some domination relations. That is to say, dominating constraints after demotion takes place become dominated. The process of constraint demotion is described as being recursive in the sense that it is repeated until constraint ranking scheme reflects correct output forms. This algorithm as represented by Constraint Demotion (henceforth CD) cannot solve all learning problems encountered by language learners, simply because it assumes constraint ranking to be linear and ordinal and this cannot give a realistic representation of the learning process for it only moves those constraints that cause incorrect realizations of output forms. A learner may, at times while the learning process is going on, need to move constraints both downward and upward the constraint hierarchy when detecting a production error so as to bring the production process into agreement with the comprehension process. Therefore, an ordinal ranking will not be realistic and sufficient enough to solve learning problems. Consequently, another algorithm

was proposed in (1998) by Boersma, that allows both the demotion and promotion of constraints at the same time; this is the Gradual Learning Algorithm (henceforth GLA).This algorithm does not move only those constraints that can cause errors but also those constraints that can help prohibit the production of such errors. Thus, the former constraints become dominated by the latter constraints and the learner's grammar becomes closer to the adult native speaker's grammar. The above mentioned two algorithms are considered as reranking strategies that learners may resort to during the learning process. This is highlighted in the coming section.

3. Foreign Language Learning and Constraint Reranking:

The basic difference between an adult native speaker of a language and a foreign language learner is that the former's grammar (i.e. constraint ranking scheme) is fixed in the sense that what s/he learns does not mismatch what s/he produces, since he has a perfect knowledge of his own grammar(in an idealized situation). The latter's grammar, on the other hand, is undeveloped. Hence, quite often what he hears mismatches what he produces; that is why he is usually in a continuous process of checking his own ranking scheme and trying to rerank those constraints which he thinks to be behind such mis- matches. Consider the case of Iraqi learners of English, at the university level, who are usually academically exposed to English phonetics and phonology during the first two years of their four–year study at the university. Being informed in such classes that the universal syllable structure is (CV) and that this is not the only structure available in English, they become aware of the existence of such syllable structures:

1. –V-	err	/ ɜ:/	9. CCCVCC	striped	/strıpt/
2. -VC	eat	/i:t/	10. -VCC	eats	/i:ts/
3. CVC	seat	/si:t/	11. -VCCC	asked	/α:skt/
4. CCV-	star	/stα:/	12. CVCC	seats	/si:ts/
5. CCCV-	stray	/streı/	13. CCVCCC	grasped	/grα:spt/
6. CCVC	start	/stα:t/	14. CCVCCCC	prompts	/prompts/
7. CCVCC	starts	/stα:ts/	15. CVCCCC	sixths	/sıksϴs/
8. CCCVC	straight	/streıt/	16. CCCVCCC	scripts	/skrıpts/

However, their awareness of such linguistic information does not mean a guaranteed correct production of some of these syllable structures. Take, for instance, the production of initial three consonant-clusters in words like splash/splæʃ/, street /stri:t/, and screw /skru:/.

Quite often Iraqi learners face a difficulty in producing these clusters, due to their absence in the learners' first language, that is Iraqi Arabic. Consequently, they resort to vowel epenthesis between the first consonant of these clusters and the second consonant, resulting in the incorrect pronunciations */sɪplæʃ/, */sɪtri:t/, and */sɪkru:/, respectively. Thus, changing the monosyllabic structures of these and similar words into bisyllabic ones. In OT terms, they rank the syllable structure constraint *Complex^{Ons}(i.e. Onsets are simple, Itô 1989, Prince and Smolensky 1993) higher than its actual position in the constraints hierarchy of English syllable structure. In other words, those learners treat this constraint as inviolable. For native speakers of English, this structural well – formedness constraint is dominated by the faithfulness constraint DEP-IO (McCarthy and Prince, 1995) which reads as follows:

DEP-IO

Output segments must have input correspondents. ('No epenthesis'). Whereas according to the Iraqi learners who insert a short vowel within initial three consonant – clusters the *Complex^{Ons} constraint is ranked higher than DEP-IO, hence resulting in the above incorrect pronunciations. This means that though such learners succeed in comprehending English syllables starting with complex onsets, they fail in producing them correctly under the influence of their own mother tongue constraint ranking scheme. The same can be said about complex final three and four consonant-clusters. Again, in such cases some learners make use of short vowel epenthesis between the second and third consonants. In other words, those learners consider the constraint *Complex^{COD} (i.e. Codas are simple) violable only to some extent that allows the occurrence of only final two consonant-clusters. That is to say the constraint *Complex^{COD} dominates the DEP-IO. So, for those learners the following foreign syllable structure constraint hierarchy at this point of their learning process is at work:

Onset>> *Complex^{Ons}>> DEP-IO

&

No-Coda>> Complex^{COD}>> DEP-IO

Note that the first dominating constraints Onset and No-Coda read as follows:

Onset

Syllables must have onsets.

No-Coda

Syllables are open.

The first constraint is satisfied in English by the occurrence of syllables having 'simple' onsets, composed of a single consonant and the second one is violated by having closed syllables, i.e. syllables ending with a simple coda. Note also that no language can allow the occurrence of complex onsets and complex codas unless it first allows the occurrence of simple onsets and codas.

Having such an erroneous constraint ranking at their disposal, Iraqi learners could never produce correct complex onsets and codas of English syllables. Upon drawing their attention to these errors or when they themselves detect those errors consciously, they start looking for solutions for this problem. To produce these syllable structures correctly, these learners need to rerank the related constraints. The reranking process may follow one of two strategies: either by demoting the * Complex constraint (in both cases of onsets and codas) below the DEP-IO constraint or by moving the DEP-IO constraint above the * Complex constraint which means promoting it. Accordingly, they either follow the CD reranking strategy or the GLA strategy. Learners may use these strategies in an attempt to get their produced forms closer to the comprehended ones. The main difference between these two reranking strategies is that while CD can only move constraints a tiny bit downward the constraint hierarchy, the GLA can shift them upward and downward the constraints hierarchy.

These two reranking strategies are also used by Iraqi learners while learning English stress. Stress in English cannot be described as being fixed in the sense that it always falls on a certain syllable in a lexical word simply because of different factors among which the morphological structure of the syllable, the grammatical category of the word, the phonological structure of the syllable and the number of syllables in a word figure out prominently. In teaching Iraqi learners English stress all of these factors are supposed to be elaborated together with an explanation of the concept of prominence which plays a vital role in stress placement in English.

For example, words like (scrutiny) /ˈskru:tıni/, (scrutineer) /skru:tıˈnıə/ and (strategic)/strəˈti:dʒık/ when presented to the learners as instances of a

trisyllabic noun having its primary stress on the first syllable or on its final syllable, and a trisyllabic adjective stressed on its second syllable, respectively, may on the one hand be comprehended without much difficulty. In production, on the other hand, they may be produced incorrectly. Note that the first word has a dactylic stress pattern / ˈ--/, the second anapestic /- ˈ -/, and the third iambic /- - ˈ/. In an attempt to produce the stress patterns of these words, learners have four incorrect possibilities (i.e. candidates) for each form. For (scrutiny), they have the following candidates:

1. /ˈsɪkru:tɪni/**2.**/sɪkˈru:tɪni/ **3.** /sɪkru:ˈtɪni/ **4.** /sɪkru:tɪˈni/

As for (scrutineer) and (strategic), they have the following candidates, respectively.

1./ ˈsɪkru:tɪnɪə/, **2.** /sɪkˈru:tɪnɪə/, **3.** /sɪkru:ˈtɪnɪə/,
4. /sɪkru:tɪˈnɪə/.

1. /ˈsɪtrəti:dʒik/, **2.**/sɪt ˈrəti:dʒik/, **3.** /sɪtrəˈti:dʒik/,
4. /sɪtrəti:ˈdʒik/

Notice that those learners have also a problem in pronouncing complex onsets, so they resort to vowel insertion to split these onsets into pronounceable parts.That is to say, upon perceiving the auditory signals of these three overt output forms, the learners underlyingly save an image of the syllabic boundaries and stress patterns of each of them. However, these stress – syllabic patterns lack feet and moras structure since they are not directly observable in the auditory signals. Thus, they should be recognized and realized by the listeners.

First of all, the main syllable structure (markedness and faithfulness) constraints that are related to the syllabification of the above three forms are the following:

1) Ons
A syllable must have an onset.
2) -COD
A syllable must not have a coda.
3) *Complex^{Ons}
Onsets are simple.
4) Parse
Underlying segments must be parsed into syllable structure.

(Prince and Smolensky, 2004: 106)

5) Fill

Syllable positions must be filled with underlying segments.(ibid)

At a certain point during the learning process, these constraints take a ranking scheme that is different from that internalized by the adult native speaker/ listener. Therefore, the foreign language learners produce the above forms wrongly, reflecting their transitional constraint ranking scheme at that particular learning point. Notice that learners may have two underlying forms for each input form, the first underlying form represents that of the perceived auditory signal, while the other represents that of the output form to be produced by them. Mismatches between the two underlying forms result in mismatches between the perceived auditory signal and the about to be produced form.

Vowel epenthesis between the first consonant and the second consonant of the initial three consonant –clusters of the above forms means that their own language lacks such complex clusters, as was stated above. Consequently, they resort to the insertion of the English short vowel /ɪ/ between the first two consonants, which result in increasing the number of syllables by one and breaking each cluster into two onsets and a coda as underlined in the following representa-tions:

/sɪkru:tıni/, /sɪkru:tınıə /, /sɪtrəti:dɜik/

Thus, the new simple onsets are /s-/ and /-r-/, whereas the new codas are /-k/ and /-t/.

In OT terms, this suggests that for these learners * Complex^{Ons} constraint is inviolable, which is contrafactual since native speakers violate it by producing initial two and three consonant –clusters. A language cannot include complex onsets unless it allows simple onsets in the first place, and this can be said about codas as well. Then, this means that in English both of the Ons constraint and the *Complex^{Ons} constraint are violable; thus, their position on the constraint hierarchy cannot be very high. However, in placing the *Complex^{Ons} constraint at the top of the hierarchy, those learners reflect their inability of producing such complex consonant-clusters. Their reranking scheme may look at this point of the learning process, as follows:

*Complex^{Ons}>> Ons>> Parse>> Fill

The above ranking scheme reads as follows: $Complex^{Ons}$ dominates (i.e. >>) the Ons constraint which allows onsets. The latter dominates the Parse constraint which for such learners allows underlying segments to connect to syllable positions different from the original ones. The Parse constraint, in turn, dominates the Fill constraint which is violated by these learners by inserting a short vowel that is not present underlyingly into a fake syllable position. Those learners, afterwards, compare between the auditory signal of the perceived form and their own incorrectly produced form, and upon detecting an error they would strive to bring their produced form closer to the perceived one by reranking the related constraints. This, of course, can take place after drawing their attention to the error they made and upon repeated correction they may make use of the learning reranking strategy which causes the $*Complex^{Ons}$ constraint to step down below the Ons constraint on the constraint hierarchy. In other words, they may resort to the CD reranking strategy; hence, their constraint ranking scheme may have a better shape than their previous one as illustrated below:

Ons>> $*Complex^{Ons}$>> Parse>> Fill

This new ranking suggests that complex onsets are allowed in the target language (i.e. English).

As for stress placement, the same learners could have a multiple difficulty in dealing with the above three forms, since as we have shown above that they may have a problem with the syllabification of these three forms; so, this can lead to the production of wrong stress patterns. Kager (op. cit.: 146) states that "in order to represent stress, metrical theory first assumes a set of universal prosodic categories in a hierarchical relation, the prosodic hierarchy (Selkirk 1980, McCartly and Prince 1986)." This hierarchy is given below:

PrWd	Prosodic word
Ft	Foot
Σ	Syllable
M	Mora

Moving from PrWd downward, every category contains the next category, standing as its head. A prosodic word is usually understood as a lexical word (noun, verb, adjective, and/or adverb) that is quite often stressed. In English, as is the case in most language, stress tends to fall on syllables containing long vowels, diphthongs or ending with codas (closed syllables). It

has a rhythmic pattern alternating strong and weak syllables so as to avoid the occurrence of adjacent stressed syllables. English rhythmic patterns are manifested in two types of metrical feet in ordinary, not poetic, language (the latter, i.e. feet, being the smallest units used for measuring rhythm) trochees in which the initial syllable is stressed, and iambs in which the second syllable is stressed. Stressed syllables are usually strong and intrinsically prominent and have quantity sensitivity. Thus, they are described as being heavy according to the Weight -to- Stress Principle (WSP) which is stated below:

WSP

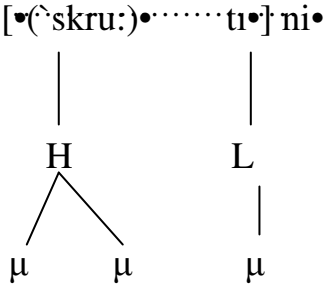
Heavy syllables are stressed. (Kager, op. cit.: 172)

Syllables are composed of the weight-bearing units, i.e. moras. Kager (ibid: 147) contends that "Universally short vowels are represented by one mora, while long vowels have two …. CV syllables are universally light (monomoraic) while CVV syllables are universally heavy (bimoraic). The weight of a CVC syllable depends on whether or not its coda consonant is moraic." Then, according to the above universal description of syllables, the three forms /ˈskru:tɪni/, /skru:tˈɪnɪə/, and /strəˈti:dɜɪk/ are all prosodic words. The first prosodic form is composed of a trochaic foot having its head at the left edge of the prosodic word, and since there is a universal constraint affirming the binary structure of feet as stated below:

Ft-BIN

Feet are binary under moraic or syllabic analysis. (ibid:156)

Hence, this prosodic word is composed of a trochaic foot that has the following rhythmic structure:



The above prosodic hierarchy reads as follows:

/ˈskru:tɪni/ has a trochaic binary foot starting from the initial syllable and ending before the extrametrical final syllable /-ni/. "extrametricality is the property of being 'invisible' to rules of foot construction" (ibid: 149).

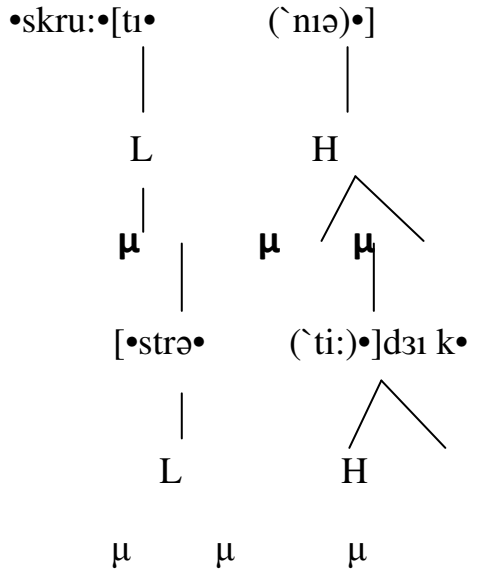
Accordingly, this trochaic foot is composed of a heavy syllable followed by a light one, which are separated by bold dots, and the final syllable is unfooted according to the NON Finality constraint which is given below:

NON Finality

No foot is final in PrWd. (ibid: 151).

The heavy syllable is composed in turn of two moras whereas the light syllable contains one mora.

As for the other two prosodic words, they have the following prosodic hierarchies.



As shown above, / skru:tɪnɪə / has an iambic foot whose head is at the right edge of the prosodic word. First of all, this metrical analysis leaves the first syllable /skru:-/ unfooted, and second violates the NON Finality constraint. This foot is composed of a light syllable followed by a heavy syllable which is the foot head. These two syllables are represented by three moras at the moraic level. Concerning the last prosodic word/strəˈti:dɜɪk /it contains an iambic foot whose head is represented by the heavy syllable /-ˈti:-/ which is preceded by a light syllable /strə-/, and the last syllable /-dɜɪk/ is again left unfooted. That is to say, at the moraic level we have three subsequent moras. The above prosodic analysis of these three words means that there are, at least, three metrical constraints interacting with each other, namely: FT-BIN, NON Finality, and WSP. Such metrical information is, of course, unobservable to learners and they

have to infer its effects through intensive practice and drilling. Even when they are academically informed about stress rules of the different types of lexical words, still the many exceptions of these rules make it harder for them to apply. Therefore, such learners often produce wrong stress patterns of polysyllabic lexical words before they really do successfully comprehend and produce them. Thus, the wrong syllabifications and stress patterns of the above three prosodic words are neither surprising nor unexpected taking into consideration the phonological differences between the native language and the target language and the difficult application of metrical rules.

Hence, learners again resort to the previously mentioned reranking strategies CD and GLA in approaching the correct production of the above words. For instance, after comprehending and correctly syllabifying such words, they may start the process of stress placement with fixing the primary stress on the first syllable of these words. This means a violation of the WSP constraint; consequently, they rank it in a lower position than its usual position. Moreover, they may treat the NON Finality constraint as inviolable, so they rank it highly on the hierarchy. However, a word like / skru:tˈınıə / proves their ranking scheme to be wrong, since the head of this prosodic word iambic foot lies on its right edge. Hence, after some practice takes place they start the reranking process either by demoting constraints or both demoting and promoting constraints. Regarding the CD strategy, they may rerank the NON Finality constraint by demoting it into a lower position on the hierarchy, and as for the GLA reranking strategy they may demote the NON Finality constraint and simultaneously promote the WSP constraint. This can result in a better ranking scheme that is guided by the target language learnability.

4. Conclusions:

Though OT has been mostly applied to child language, however this study attempts to show that language learnability by means of a continuous process of reranking interacting constraints can be applied even to a foreign language learning process. Iraqi learners of English at the university level are taken as a case study concerning the processes of polysyllabic words syllabification and stress placement. English differs from these learners' first language, i.e., Iraqi Arabic, in syllable structure and stress pattern, among other things. This means, in OT terms, that these two languages have two different ranking schemes of constraints regarding these two issues. Therefore, it is not surprising for such

learners to encounter difficulties in syllabifying English polysyllabic words and then marking them with, at least, the primary stress. This however, does not mean that all Iraqi learners would have such a difficulty in both comprehending and producing those words. A good number of them find the topic of English syllable structure not quite difficult to understand, and many of them could correctly analyse the syllable structure of different English words. Yet, this does not mean that those words would be easy for them to produce, particularly those containing complex onsets and complex codas which can force some of them to simplify such syllable margins by vowel epenthesis. The wrong syllabification of English poly-syllabic words with syllables opening and closing with complex margins means that these learners' related constraint ranking scheme is erroneous and needs to be amended making use of the two reranking strategies CD and GLA.

Furthermore, the process of stress placement is not really fixed in English. It, firstly, depends on whether or not the word is lexical or grammatical, though the latter can also be stressed at very specific positions and for different reasons. In addition, syllables' quantity which is manifested differently in heavy and light syllables is considered as a factor of vital importance in stress placement. Therefore, it would not suffice to inform learners which syllable should be stressed in a noun, a verb, an adjective or an adverb since there are many exceptions to the rules. Accordingly, attracting their attention to metrical information that is guided by a simplified version of OT analysis may help these learners to not only better comprehend the stress concept but also to correctly produce stress patterns. This, however, could not be claimed to be a straight forward solution to wrong productions of stress patterns. Such productions would still occur and this does not mean that the case is hopeless. It, actually, means that the internalization of the related constraints and their correct ranking scheme is not yet clear and complete and it is only a matter of time for the learners to conclude the correct ranking scheme by making use of reranking strategies. "For a learner to have learned anything, he must arrive at a hypothesis which no future token could cause him to abandon (Gold, 1967). Such a hypothesis may be compatible with all of the overt forms of the language in which the learner is immersed" and a learner is considered successful in his learning process if he "arrives at a grammar whose yield (i.e. outputs) is the same as the target's yield, i.e. if the grammars have the same "extension" " (Tauberer, 2009: 229). In other words, a successful language learnability means a successful deduction of the constraints ranking scheme in question on the part of the learner that brings his newly constructed grammar into a total agreement with the target grammar.

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